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PROCESS FOR THE DISPOSAL OF SULFUR

The present invention relates to a new process for the disposal of sulfur.

10   More specifically, the present invention relates to a new process for the disposal of sulfur coming from the purification treatment of hydrocarbons of a fossil nature, for example crude oil or natural gas.

It is well known that sulfur can be present in considerable quantities in both extracted crude oil and natural

15   gas. In this gas, the sulfur can be present in the form of H_2S in a percentage molar quantity which can reach 10% and in particular certain cases it can even exceed 20%, referring to gas.

20   When present in high concentrations in gas, the hydrogen sulfide is separated using various systems, of which the most widely used is absorption in solutions of ethanol amines. Once it is in the concentrated state, the hydrogen sulfide is transformed into elemental sulfur by means of

25   the Claus process. At this point, it is necessary to allo-

cate the sulfur which, for the last few years and poten-
tially for tens of years to come, has a market character-
ized by an excessive offer with respect to the demand. Sul-
fur is normally stored in elemental form as huge blocks
5   which require continual monitoring and treatment of the run
off water to avoid the acidification of the ground and sur-
rounding underground water. In addition to this, there is
an increasingly strict legislation on the part of states
containing oil fields or natural gas reservoirs, which in
10 some cases impose heavy penalties for the storage of recov-
ered sulfur.

The Applicants have now found an innovative process
for the elimination of said large quantities of sulfur
which envisages its injection into the ground by pumping it
15 in the liquid state into adequate geological structures.
These structures can consist of the field itself from which
the crude oil or associated gas has been extracted or other
adequate geological structures, such as abandoned mines or
saline aquifers.

20   Thanks to the solution, object of the present inven-
tion, a permanent sulfur storage is obtained without any
risk of its leaving the surface and contaminating usable
groundwater or negatively interfering with the extraction
process of crude oil/gas. Large accumulations of sulfur do
25 in fact exist in nature in indefinitely stable geological

structures and without having a negative impact on the sur-
rounding environment.

An object of the present invention therefore relates
to a process for the disposal of sulfur which comprises
5 heating and melting the sulfur, optionally in the presence
of hydrogen sulfide, and injecting the molten sulfur, in
liquid and homogeneous form, into geological structures
having a temperature ranging from 90 to 160°C.

The present invention envisages the pumping of sulfur
10 in liquid form through surface pipes, well pipes and re-
ceiving geological structures. The molten elemental sulfur
can come directly from the Claus process or from a surface
storage site.

The pressure necessary for pumping the liquid obtained
15 from the liquefaction of sulfur into a pipe can be calcu-
lated with the general formula:

$$\Delta P = 2f \bullet \rho \bullet u_m{}^2 \, L \, / \, D_{eq}$$

wherein L is the length of piping used for injection into
the geological structure. D_{eq} its equivalent diameter, u_m
20 the average rate of the fluid pumped, ρ the density of the
fluid pumped and f the friction factor which is a function
of the roughness of the pipe and Reynolds number:

$$Re = D_{eq} \bullet u_m \bullet \rho/\mu$$

wherein μ is the kinematic viscosity of the fluid. The
25 pumping device can be represented by a conventional pump

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capable of processing fluids at temperatures ranging from 90°C to 160°C. The viscosity values of the sulfur in the molten state within the temperature limits indicated are specified in Table 1 below.

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<u>Table 1</u>

Viscosity of molten sulfur in relation to the temperature

Temperature (°C)	μ (cPoise)
119	11.45
125	10.31
132	8.84
140	7.67
150	6.62
157	6.72
160	11.6

The geological structures which are appropriate for receiving the molten sulfur are those having temperatures ranging from 90°C to 160°C and, preferably, those forming the reservoir itself from which the crude oil or natural gas containing sulfur in the form of organic compound or hydrogen sulfide, are extracted. Alternatively, geological structures can be used, in a remote position with respect to the reservoir and having structural characteristics suitable for receiving and preserving the molten sulfur.

For the application of the present invention, either

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matrix geological structures or fractured structures, natu-
rally or induced, can generally be used. In all cases, the
pressure and maximum injection flow-rate of the fluid form-
ing the molten sulfur, optionally mixed with hydrogen sul-
5   fide, can be determined by calculations and measurements
well known to experts in stimulation treatment of produc-
tion wells or the production and running of water re-
injection wells.

The present invention requires the injection of sulfur
10   in liquid form with a low viscosity. In the case of pure
elemental sulfur, the appropriate conditions for the appli-
cation of the present invention are obtained for tempera-
tures ranging from 119°C to 160°C. The field of application
of the disposal process of sulfur, object of the present
15   invention, can be enlarged by mixing elemental sulfur with
other compounds capable of lowering the melting point of
the mixture. A valid and economical system for reducing the
melting point of sulfur consists in mixing it with H_2S un-
der pressure. Table 2 below indicates the melting points
20   (Tm) of sulfur in the presence of H_2S at different pressure
values. In this way it is possible to lower the melting
point of sulfur from 119°C to 90°C approximately.

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<u>Table 2</u>

Influence of the H_2S pressure on the Tm of sulfur

Melting point of sulfur (°C)	H_2S pressure (bar)
119	0
115	1
111	12
106	24
100	39
100	40
94	58
91	80
91	90
90	110
90	125
90	155

This lowering of the melting point of sulfur is veri-
fied, even if to a lesser degree, also when hydrogen sul-
fide is mixed with other gases without an analogous effect,
such as, for example, methane or carbon dioxide. From the
following table it can be observed how, at a fixed pressure
(for example 200 bar) the melting point of sulfur decreases
with an increase in the concentration of H_2S in the mixture
with methane.

Table 3

Influence of the concentration of H_2S in methane on the melting point of sulfur at 200 bar

Melting point of sulfur (°C)	H_2S percentage in methane
119	0
117	4.5
115	9
114	14
109	25
92	100

The possibility of applying the present invention also using hydrogen sulfide mixed with methane can prove to be economically advantageous if the receiving geological structure is at a sufficiently high temperature and the use of the mixture with methane can avoid the necessity of a separation process of methane from hydrogen sulfide.

Finally, it should be noted that the disposal system of sulfur, object of the present invention, allows part of the hydrogen sulfide separated from the associated gas to be used to fluidize the sulfur produced with the Claus process, thus reducing the total volume of H_2S to be sent to the Claus process itself.

Therefore, with respect to the practical embodiment of the present invention, the disposal process of sulfur

should therefore be effected by selecting a suitable recep-
tive geological structure having a temperature ranging from
90°C to 160°C, optionally mixing the sulfur with hydrogen
sulfide (preferably pure) so that the melting point of the

5 mixture is lower than or equal to that of the receiving
geological structure, heating the sulfur (or mixture) to a
temperature which is sufficiently higher than the melting
point so that, during the pumping process at the surface
and in the well, the sulfur (or mixture) remains in the

10 liquid state and, finally, pumping the sulfur (or mixture)
into the reservoir through possibly insulated pipes.

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